ROLE OF MODIFIED PHEMISTER BONE GRAFTING IN NON UNION AND DELAYED UNION OF FRACTURES OF LONG BONES

THESIS

For

MASTER OF SURGERY

(ORTHOPAEDICS)

BUNDELKHAND UNIVERSITY
JHANSI (U. P.)

1995 **GOKUL PRASAD**

C E R T I F I C A T E

This is to certify that the work entitled "MODIFIED PHEMISTER BONE GRAFTING IN NON UNION AND DELAYED UNION OF FRACTURES OF LONG BONES, which is being submitted as a thesis for M.S.(Orthopaedics) Examination, 1995 of Bundelkhand University, has been carried out by Gokul Prasad in the department of Orthopaedics, M.L.B. Medical College, Jhansi.

He has put in the necessary stay in the department as per university regulations.

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Dated : 2.1.95

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A C K N O W L E D G E M E N T

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(Gokul Prasad)

C O N T E N T

I N T R O D U C T I O N

INTRODUCTION

Delayed union and non-union are fairly formidable problems which occur in fracture of long bones due to many causes. It is often taught that non-union is an irreversible process in which the bone ends are joined together by mature fibrous tissues having no inherent capacity to reossify. Based on this assumption all previous attempts were made to excise the fibrocartilagenous bridge and medullary canal was opened by removing the sclerosed bone ends so that the endosteal and intermediary callus could reforms. This excision of bridge made the bone ends free and unstable, which required the need of stabilization by some external means i.e. massive cortical graft, metal plate and screws or nails.

The earlier procedures used in past were major surgeries. They were quite shocking and therefore needed pre-requisites such as presence of healthy skin cover and absence of any dormant infection which could convert the graft into sequestrum, which become a source of perpetuation of infection.

Moreover, the massive cortical graft which is taken from opposite tibia also carries the risk of fracture of tibia.

The cortical graft which was used in cases of delayed union and non-union was not osteogenic. This

was stated by many workers that sole source of osteogenesis is the living bone on which the graft if placed.

It acts as the mechanical strut at fracture site but the strength provided by graft is no where near equal as compared to the metallic internal fixation devices like screws and plate or nail. Thus ideal combination would be using the internal metallic fixation for mechanical support and chips of cancellous bone at the fracture site or pseudarthrosis to induce the osteogenesis(Charnley,1957).

Elmslie (1920) first demonstrated that leaving the fibrous union undisturbed because it acts as stabilising medium like screws, plates and nails. In fact this fibrous or fibrocartilaginous union or bridge is not used less, it had been stated by various workers that this medium also acts as induction medium for osteogenesis as by Elmslie. (Jackson and Burrows, 1940). Elmslie used a simple inlay grafting technique accross pseudarthrosis and relied on its accurate fit to dispense with any metallic fixation.

A more dramatic demonstration of osteogenic potential in case of delayed union and non-union of long bones or pseudarthrosis was brought out by Dunn (1939) in a different manner. He said even the bone grafts are unnecessary and stated that to treat the cases of delayed and non-union it sufficed to turn up the flakes of periosteum covered bone with chisel and mallet in a

manner which he called "subcortical procedure". This procedure is now-a-days called shingling. The success of this method again depends on presence of intact fibrous bridge or union between the bone ends.

Phemister (1947) drew attention towards the fact that there was a simpler short and safer method than massive cortical graft and internal metallic fixation by screws, plates and nails. Procedure advocated by Phemister was revival of Elmslie technique. He relied on subperiosteal placement of cortical bone grafts and retained them in position by tight suturing of the overlying soft tissue. He did not use plates, screws and nails to stabilize the bone ends because he left fibrous bridge undisturbed. He said that introduction of foreign material served as source of trouble in potentially infected scar tissue. He achieved bony union in 46 patients out of 49. Phemister thus made his first clear statement which is now accepted as axiomatic in bone grafting for non-union as quoted by Charnley (1957):

1. The fibrous union need not be broken down, nor disturbed , nor the bone ends be refreshened or resected.
2. Fibrous bridge between bone ends ossifies spontaneously when grafts are placed on surface to induced osteogenesis.

3. Rigid immobilization of graft by screws is not necessary if grafts were placed subperiosteally on surface of pseudarthrosis.
4. Such a subperiosteal graft can be used in the presence of recent sepsis if inserted through normal tissues away from the site of original wound on sinus.

Later Forbes (1947) advocated the different technique of bone grafting in cases of delayed union and non-union. He elucidated the osteoperiosteal flaps at fracture site which he called as shingles and grafts were placed on either side of fracture site then vertical mathress sutures were applied to close the wound.

Charnley (1957) published his paper and gave credit to Elmslie, Dunn and Phemister with his own modification. He combined the procedures of all mentioned above with substituting the cancellous bone graft in place of massive cortical graft taken from tibia. He taken the cancellous strips grafts from ilium of same individual 2 mm thick which is superior to cortical graft and has superior osteogenic potential more resistant to infection, and normal tibia is not violated. The grafts were used in cases of delayed and non-union were autogenous in nature.

Jarry and Uhthoff (1960) advocated the "Petal technique" to treat the cases of delayed and non-union

of long bones. The term "petal" described triangular pieces of cortical bone with their bases attached to the bone. Multiple petals are made on either side of fracture site which induces the osteogenesis by increasing neovascularization.

In present study we have combined Forbes modification of Phemister technique (1961) with that of Jarry and Uhthoff (1960) for preparing the bed of bone, in cases of ununited fracture of tibia.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The early history of bone grafting was dominated by lectures and teaching of various authors.

The classical work on transplantation of bone was originated in beginning of Nineteenth century with the classical experiment of John Hunter (1937) and including such famous Names as Macewen (1912), Hey Groves, Gallie (1831) and Phemister (1914-47).

Albee (1915) did the lot of work on bone grafting and history of bone grafting started by his teachings. He used a cortical graft to make a cabinet makers joint.

Chutro (1918) described revolutionary technique of bone grafting which bears the similarity of todays cancellous bone grafting but graft was taken from tibial cancellous bone.

Delageniere (1918) reported that only osteo-periosteal grafts are sufficient to induce the osteo-genesis and for successful result in delayed and non-union without anchorage them by plaster, screw, and nails which he said best way of treatment.

Campbells (1919) modified the technique of Hutingtons which he made gutter in lateral condyle of tibia to accommodate the head of fibula.

Albee (1919) introduced the technique of inlay cortical grafting successfully.

Gallies and Robertson (1919) explained the fate of graft that dead graft is transform into living bone by invasion from host sources. This mechanism of transformation also explained by 'Phemister (1914), Kiehn et al (1952), Lloyd Roberts (1952) and Wilson (1951).

Elmslie (1920) postulated that ends of bone in non-union and delayed union has osteogenic potential and which can release by trivial operative procedure. In past which was not known by majority of surgeons.

Harkins and co-workers (1920) used simple onlay grafting technique in 39 cases of delayed and non-union and achieved bony union in 38 cases.

Campbells (1921) used onlay bone grafting with fixation of graft by screw to promote osteogenesis and mechanical stability. This was the original technique of Handerson which he had Hone in 633 cases and union was achieved in 561 cases.

Hibbs (1924) described a technique of bone healing of spinal fusion operation by placing the iliac cancellous bone grafts in 59 cases of scoliosis.

Robde (1925) described the fate of transplanted graft that its cells can only survive provided that graft is autogenous and its texture such as to

facilitate rapid diffusion of host tissue fluid into graft and early vascularisation of graft by host but apponent of this also co-exist.

Lexer (1925) described the first allografting technique and obtained good results.

Kirschner (1926) described a method of treating the cases of delayed and non-union by splitting of bone ends, which releases the osteogenic potential to osteogenesis at non-union site. Method was very good.

Beck (1931) introduced a method to induce the osteogenic potential by multiple drilling but not used now-a-days.

Hadri (1931) introduced a method of introduction of local injection of osteogenic potential at delayed and non-union site, which was called as 'essocal' which is bone glue knitted and placed either by open reduction or local injection. But there is no other literature on this.

Gallies (1931) published his early work showing superiority of cancellous bone graft over cortical bone graft.

Phemister (1931) rejected the use of strip graft from tibia and advocated a solid onlay graft from sound opposite tibia, the Phemister (1947, 1951) continued to use the cortical tibial graft which

concluded that results were highly successful. The full thickness cortical graft has endosteal cancellous bone.

Siegling John (1936) used horn of cow as bone graft and studied the fate of horn which was not to much successful.

Dunn (1939) gave a revolutionary technique and said that bone grafts are unnecessary. It suffices to turn up flakes of periosteum, covered bone in a manner which he called "Sub cortical procedure" which now-a-days called as Shingling. The success of this procedure depends on intact fibrous or fibro-cartilagenous bridge between bone ends. Mitch (1939) described the technique to create the tibio-fibular synostesis for non-union of tibia.

Jackson and Burrows (1940) also used the similar technique of Phemister (1931) and used cortico-cancellous graft without disturbing the fibrous bridge. He used the inlay grafting technique and achieved union in 80% of cases and said that intervening soft tissue act as bridge and has osteogenic potential. Trueta and Barner (1940) noted that long leg cast not be removed unnecessarily in infected cases of non-union to avoid destruction of granulation tissue.

Cretin (1940) worked on non-union in long bone fracture. Comminuted fracture leads less non-union

because they give more surface area of contact and soft tissue which favourably induces the osteogenesis. But transverse fractures leads to more non-unions.

Boyd (1941) devised operation in established non-union and pseudo-arthrosis. He used two onlay graft which was of cortical in nature. He described the use of dual onlay graft near joint and in osteoporotic patients.

Bishop and associates (1941) also realised the use of dual onlay graft in established non-union which he considered the best technique and operated the 358 cases of non-union successfully with 93% good results.

Coleman and associates (1942) treated the cases of infected non-union cavities, sinus by sequestrectomy and filling the defect by cancellous bone graft. Kelly and associates (1942) also did the same work.

Watsonjones and Coltart (1943) gave the early limited intervention of periosteum and application strip cancellous bone graft promote union and most cases united in 12 to 16 weeks.

Mowlem (1944) also did the same work of as Jackson and Burrows (1940) technique in delayed union and non-union in seventy five cases to replace the defect of skull, mandible and long bones.

Harmon (1945) used postero-lateral approach with bone graft lying posterior to interrosseous membrane. This approach was accepted by various workers in non-union of tibia. Jone and Barnett (1955), Lamb (1969), Freedland and Meetz (1976), Weinberg et al (1979), Reekling Water (1980), Simon and Hogmartin (1984) and Simpsen (1990) used same approach.

Higgs (1945) reviewed 60 cases of non-union of long bones, treated by bone grafting 20 cases with cortical and 40 with cortical and cancellous both with 100% good results.

Murray (1946) used cortical bone graft (single) in hundred cases of non-union of scaphoid succeed in 96 cases out of 100.

Groves and Gill (1947) developed the technique of filling the defect in long bones tibia and femur by using hemicyclindrical grafts which act as massive sliding graft.

In the same year Bishop (1947) worked on dual only graft and noted the deficiencies of cortical grafts.

Abbott and Bost (1947) established beyond reasonable doubt superiority of cancellous graft over the cortical graft.

Gill (1947) introduced the technique of sliding massive cortical graft in arthrodesing the joint.

Phemister (1947) even knowing the superiority of cancellous graft, continued to use the cortical graft which was highly successful.

Planagan and Burem (1947) developed the technique of filling the defect of long bones that of tibia and femur by using opposing cylindrical graft. These grafts are very useful in gaps more than 1½" to 2½" They fixed the graft by transverse screws.

Harwitz (1951) said that graft is invaded by pleuripotant cells which are of mesenchymal origin.

Judet (1951) did the same technique of Phemister and accepted the term phemister graft which means any kind of cancellous or cortical graft.

Balthasar (1952) used splitting technique in his cases and achieved very good results.

The technique of phemister onlay tibial grafting was continued himself and accepted in different centres of world in unmodified form (Judet, 1951; Miller and Markin, 1951; Coventry, 1953; Hammasy, 1958; Mc Carroll, 1961; Ottolenghi, Labour and Japas, 1961).

Anderson (1953) used barrel staves graft in 81 tibial fractures and all were united.

Ray et al (1954) showed the experimental study of survival of osteoblast and its proliferation in tissue culture even after slow freezing. Campbells et al (1953), Mosiman (1951), Ray et al (1952) and Willis

(1936) showed that cellular survival provided graft is autogenous.

Abbott et al (1947), Ham (1952) and Ham and Gordon (1952) opposed to this hypothesis and said that after transplantation of graft, the presence of any living cells in it, is not of survive but due to invasion from host tissue (Lacroix, 1951; and Siffert, 1955).

Siffert (1955) showed that when autogenous graft is transplanted in defect of bone they invaided by host tissue from ends of host bone. He gave the two observations.

Larger the surface area of travecullae more direct will be the growth of osteogenic tissue and liberation of osseo-protein from cut surfaces of graft which causes fibroblastic reaction in osseous tissue.

The third hypothesis of osteogenesis was given by Harwitz (1951) and Lacroix (1947). They showed that transplanted graft was invaided by pleuripotent cells of connective tissue which are of mesenchymal origin. The cancellous graft is good forest for invasion but cortical graft is impenetrable forest.

Watsonjones (1955), Abbott et al (1947), Dick (1946) and Higgs (1946) said that it is clear from clinical and experimental study that cancellous graft is superior than cortical graft.

Jones and Barnett (1955) used strip cancellous graft effectively in infected non-union, by utilizing the posteromedial approach in 10 cases with 90 percent success rate.

Nicoll (1956) described a technique of bridging the gaps of long bones by use of solid blocks of cancellous grafts combined with internal fixation. He did his technique in 27 cases and achieved the union in all with average time of 14 weeks.

Wilson (1957) used the method described by Forbes. It is resume to the paper of Wilson, who does not free the bone ends and showed that cancellous bone grafting not only highly effective in clean cases but also in mild sepsis and compounds ones. He did in 22 cases and 20 were united.

Charnley (1957) advocated and accepted that in delayed and non-union, the bone ends have the osteogenic potential. He combined the method of Phemister, N'Dunn and called as subcortical iliac bone grafting, and gave credit to all and combined the procedure of Elmslie, Dunn and Phemister with his own modification.

Block (1958) studied the osteogenic potential in non-union of adhesive material and proved that any adhesive have no such potential.

Jarry and Uhthoff (1958, 1960) gave the technique of that of "Petal" for activation of osteogenesis in 278 rats then this technique was applied in human beings. Experiment shows that direct trauma release osteogenic potential at non-union site.

Forbes (1961) raised osteoperiosteal flaps of bones and used cancellous chip grafts in 29 patients. Union occurred in 27 cases. This method was called as modified phemister or subcortical iliac bone grafting.

Souter (1969) used cancellous strip grafts in 102 cases of delayed and non union. and achieved the bony union in 84 of fractures.

Carpenter and associates (1952) reported 75% of non union in displaced comminuted open fractures. Kuntzmann and Meyer (1958) reported 9% of non union and delayed union in his series.

Chalmer (1959) did the basic research on allogenic bone grafting.

Russe (1960-68) did grafting in non union of scaphoid and achieved union in 80% of cases.

Dehne (1961) said that non union is more common in tibial shaft fracture. Boyd, Lipinski and Willi (1961) said that infection worsens the prognosis of non union.

Freeman and Peter (1962) did grafting in non union and achieved union in single bone grafting. Heiple Chase and Herndon (1963) showed that allograft can be

used in place of autogenous bone graft but its immunogenecity must be reduced.

Nicoll (1964) surveyed 705 cases of tibia and reviewed 474 cases and treated them conservatively and he said that internal fixation is not the treatment of choice but Muller and associates (1963) claimed it as treatment of choice.

Merle d' Aubigne (1965) noted that rate of infection is higher, if operation is done in previously infected cases.

Hanson and Eppright (1966) noted that interroseous membrane is barrier against infection. Sethi and Singhvi (1967) combined the Charnley's modification of phemister with technique of Jarry and Uhthoff and obtained good result in 48 out of 50 cases.

Goldstein (1969) said that to achieve solid union in spinal fusion surgery long term immobilization is needed.

Saunder (1969) studied autogenous cancellous bone grafts in delayed and non union in hundreds of cases. Modern technique of grafting was used in 2 out of 100 cases and achieved good results with success of 84% bony union and average time for union was 16 weeks.

Lance (1972) in the series of his cases, reported that allogenic grafts induced immunological reaction which impaired the vascularity of graft.

Kelly and Paradish (1975) showed that mineralisation decreased at fracture site due tc decreased blood flow. Latter Rhinelander (1975) described two stage technique of infected cases debridement and bone grafting till appearance of healthy granulation tissue.

Weleor and Ceck (1976) described open bone grafting technique in infected non unions.

Nade and Burwell (1977) said that allograft accepted rapidly if autologous mass is added to site. Malanin, Rosomoff and Sulton (1977) used femoral head allograft. Burri and Wolter (1977) showed that load and compression is transmitted through graft which help in replacement of transmitted bone.

McCollum (1978) described many techniques of arthroplasty of total hip by allograft insertion.

Malanin and Braun (1971) noted taking of grafts from iliac crest consumed more time and increased blood loss. Malanin and Braun (1981) used femoral head allograft. Salama (1983) said that allograft accepted rapidly in addition to autologous mass.

Aurohi Kumar et al (1984) showed allogenic graft of femoral head is superior than autogenous graft.

Chacha (1984) did grafting technique in scaphoid nonunion. Stabler (1985) reported failure of allograft in spinal fusion in children. Burwell and Wilson (1985) reported that re-establishment of blood flow in graft might be a source of new bone formation.

Tothill (1985), Bergmann, Shoutens and Verhas (1979) showed radioactive nucleotide is inacurate method of blood flow measurement.

Tomford et al (1986) noted transferance of infection through graft. They studied the guidelines for its collection, storage and suitability of graft material.

Friedlander (1987), Goldberg Stevension (1987) and Horowitz (1987) reported that allogenic grafts are immunogenic. Hall (1987) showed blockage of capillary in immune rejection reaction by mononuclear cells.

Maurer and Dillins (1987) avoided the previous infected area and did proximal and distal synostosis.

Yamato (1988) gave simple grafting technique utilizing the pronatus quadratus as muscle pedicle graft. Dodd et al (1988) worked on scoliosis by using allograft in place of autogenous graft and said that allcgrafts are superior.

Gordon et al (1988) treated infected non union by bone grafting and all united but few needed salvage of limb.

Paley et al (1989) used newer technique in infected non union as ilizarov technique and vascularised fibular graft.

Rijnberg, Linge et al (1990) used central grafting technique in persistent non union of tibia

in 46 cases. 45 cases were united with only single failure.

Braun (1993) gave grafting technique in delayed and non union of scaphoid.

Photo I : Instrument Trolley.

Photo III: Showing technique of raising petals.

Photo II : Showing technique of raising Shingles.

MATERIAL AND METHODS

MATERIAL AND METHODS

The study was conducted in the department of Orthopaedics Surgery, M.L.B. Medical College and Hospital, Jhansi during the period from March, 1993 to September, 1994. Ten cases of the delayed and non union of tibial shaft fractures coming to the O.P.D. of the hospital were included in the study. Each patient was subjected to thorough clinical and radiological examinations. Before starting the operative procedure all patients had necessary pathological investigations.

The patients who were detected pre-operative anaemia, were given pre-operative haematinics proteins, anabolic steroids and appetizers. In some patients pre-operative blood transfusion was done.

SURGICAL TECHNIQUE

The patient was laid supine. Parts were painted and drapped properly. In leg an anterior incision was made at fracture site cutting through skin fascia, periosteum and down to the bone. Periosteum was not reflected. The osteo periosteal flaps were raised on either side of fracture with the help of 5 mm sharp osteotome. These osteoperiosteal flaps have been described as "Shingles" and the technique of so exposing the bone called as shingling. The fibrous union between the bone ends. Slices of cancellous bone were harvested from ipsilateral iliac crest in usual manner and wound, closed in layers & continuous suction drain was used.

Posteromedial and posterolateral border of osteoperiosteal flaps were incised to accomodate the flaps easily and not to interfer in the closure of wound.

Multiple petals raised extensively on exposed bone fragment on either side of fracture. Then 2 mm thick autogenous cancellous grafts were placed to the bone mostly by a lateral surface and wound was closed in two layers. Continuous suction drain was used. A/K POP slab was applied till removal of stitches. After eventual removal of cast gradually increasing weight bearing on the limbs was permitted and encouraged as tolerated till patient was able to bear weight fully on the affected limb. Also active mobilixation of adjoining joints carried out till the full movements were achieved.

POST OPERATIVE CARE

Stitches were removed after two weeks and a above knee POP cast was applied. The non weight bearing ambulation was allowed upon crutches. This walking cast was removed at about 2 months and progress of union reviewed clinically and radiologically. If still not satisfactorily united another A/K POP cast was applied for four to six weeks.

FOLLOW UP

Patients were discharged at suitable time after operation with detailed instructions regarding

do's and dont's and were followed up clinically and radiologically at 4, 8, 14 and 18 weeks intervals. All relevant data were filled and tabulated in the following way so as to reach the final results :

a. Wound scar:healthy linear scar/unhealthy linear scar.

b. Callus - Radiologically - weeks 6, 10, 14, 18.

c. Movements of knee joints, ankle and subtalar joints.

d. Date and time of removal of cast.

e. Return to employment in working patients in weeks.

O B S E R V A T I O N S

OBSERVATIONS

The study was conducted in the department of Orthopaedic Surgery, M.L.B. Medical College and Hospital Jhansi during the period from March, 1993 to September, 1994 in 10 cases of delayed and non union.

I. SITE OF FRACTURE

In our study of 10 patients four had the fracture of lower 1/3 of tibia, three had fracture of tibia at junction of upper 1/3 and lower 2/3. Rest three had fracture at middle of shaft of tibia.

TABLE I : Incidence of site of fracture.

Site of fracture	No.of cases	Percentage
Upper 1/3	3	30.00
Middle 1/3	3	30.00
Lower 1/3	4	40.00
TOTAL	10	100.00

II. SIDE OF FRACTURE

In our study of 10 patients eight patients had fracture of right leg and rest two had fracture of left leg.

III. TYPE OF FRACTURE

Seven fractures were simple and rest three were compound injury. Thus incidence of compound injury in our study was 30 percent.

IV. AGE INCIDENCE

In our series of 10 cases, 90 percent cases were of younger age group and rest 10 percent only touched the line of middle age group.

TABLE II : Incidence of age.

Age group (years)	No.of cases	Percentage
20 - 40	9	90.00
40 - 60	1	10.00
TOTAL	10	100.00

V. NATURE OF ACCIDENT

In our study of 10 cases during the period allocated, 90% cases were of road accidents and 10% were of domestic injury.

TABLE III : Incidence of nature of accidents.

Nature of accidents	No.of cases	Percentage
Traffic	9	90.00
Domestic	1	10.00
Industrial	-	-
Sport	-	-
Not known	-	-

VI. RADIOLOGICAL CLASSIFICATION OF FRACTURES

TABLE IV : Type of fracture.

Type of fracture	No.of cases	Percentage
Transverse	6	60.00
Short-oblique	3	30.00
Oblique	1	10.00
Comminuted	-	-
Segment	-	-
TOTAL	10	100.00

VII. POST OPERATIVE ASSESSMENT

The results of operation were drawn by comparing the clinical and radiological union achieved after operation.

CLINICAL

1. Absence of abnormal movements.
2. Absence of local tenderness.

RADIOLOGICAL

1. A.P. View.
2. Lateral skiagram

CRITERIA FOR RESULTS ASSESSMENT

There were four categories of assessment of functional results.

1. **Excellent**
   - No symptoms
   - No limp
   - Return to employment
   - No support.

- Full range of movement at knee and ankle
- All sports.

2. Good

- Minor complaints
- No limp.
- No support
- All sports.
- Return to original employment.
- 25% of limitation of movements at ankle.

3. Fair

- Generally symptoms.
- Aggravated by cold and calm weather.
- Slight limp
- Occasional use of cane.
- Change to a lighter occupation.
- 50% of limitation of movement at ankle.

4. Failed/Poor

- Constant pain
- Constant limp
- Use of cane
- Sport activity limited.
- Not able to return to work.
- 75% limitation of movement of joints.

The functional assessment of results was made on the basis of loss of function of a given joint. It is the significant loss.

1. At knee : Any loss of extension or loss of more than 10^{o} of flexion.

2. At ankle : More than 25% loss of extension or flexion movement.

3. At tarsus : More than 25% of loss of inversion or eversion movements.

Longer immobilization in plaster cast inflicts the joint stiffness more. Therefore to reduce this post immobilization residual joint stiffness. Muller (1963) used internal fixation to immediate free use of the joints.

VIII. DEGREE OF STIFFNESS

- Severe stiffness : over 50% of loss of extension and flexion movements at ankle in one patient.
- Both combined at ankle and foot in one.
- Two had stiffness in knee and failed grafting in only one case.

TABLE V :

Movements involved	Ankle	Foot tarsus	Both	Knee
Extension	-	-	-	1
Flexion	-	-	1	-
Both	-	-	-	-
Inversion	-	-	-	-
Eversion	-	-	-	-
Both combine	-	1	-	1
Extension + inversion	-	-	-	-
Flexion + eversion	-	-	-	-
TOTAL	-	1	1	2

IX. INTERVAL BETWEEN INJURY AND GRAFT

The longest interval between the injury and grafting was 8 months and shortest was fifteen weeks or 105 days. Average time for grafting was 22.3 weeks. Average time for graft and union was 19.5 weeks. Average injury and union time was 9 months.

TABLE VI : Results of tibia grafted - analysis.

Case No.	Time interval		
	Injury/graft (weeks)	Graft/union (weeks)	Injury/union (months)
1	28	12	10
2	14	18	8
3	20	17	9
4	14	14	7
5	32	-	-
6	24	24	12
7	24	26	-
8	24	20	9
9	23	22	9
10	20	23	8.5
10	22.3	19.5	9

TABLE VII : Results of grafted tibia within 20 weeks.

Case No.	Time Interval		
	Injury/Grafts (weeks)	Graft/union (weeks)	Injury/union (months)
1	28	12	10
4	14	14	7
9	24	20	9
3	22	15	8.5

Average time interval :

Injury/graft : 22 weeks

Graft/union : 15 weeks

Injury/union : 8.5 months.

X. RESULTS OF TIBIA GRAFTED(CLEAN CASES)

TABLE VIII : Analysis of clean cases.

Case No.	Time interval		
	Injury/graft (weeks)	Graft/union (weeks)	Injury/union (months)
1	28	12	10
4	14	14	7
5	32	-	-
6	24	24	12
8	24	20	9
9	23	23	9
10	20	20	9
7	23.2	18.8=19	8.8=9

Average time intervals :

Injury/graft = 23.2 weeks

Graft/union = 18.8(19) weeks

Injury/union = 8.8(9) months

XI. INFECTED CASES

TABLE IX : Results of tibia grafted analysis.

Case No.	Time interval			Type of fracture
	Injury/graft (weeks)	Graft/union (weeks)	Injury/union (months)	
2	14	18	8	Open
3	20	17	9	Open
7	24	26	-	Open
3	19.3	17	8.5	

TABLE X : Results of surgery.

Result achieved	No.of cases	Percentage
Excellent	6	75.00
Good	1	12.50
Fair	-	-
Poor/failed	1	12.50
TOTAL	8	100.00

Success = 87.50%

TABLE XI : Average operation time.

Case No.	Time taken in operation(min)
1	90
2	100
3	110
4	90
5	90
6	98
7	120
8	95
9	98
10	100
Average time = 99.1 minutes.	

TABLE XII : Average time for complete removal of cast.

Case No.	Removal time of cast(weeks)		
	I cast	II cast	III cast
1	6	10	-
2	6	10	16
3	6	12	15
4	6	10	16
5	7	12	- Left
6	8	12	-
7	6	13	16
8	6	10	15
9	6	12	14
10	7	10	16
10	64/10=6.4	111/10=11.1	108/7=15.4

TABLE XIII : Bridging callus.

Case No.	Time of callus(weeks)	
1	8	
2	6	
3	6	
4	8	
5	8	
6	-	Left
7	-	Left
8	-	Failed
9	6	
10	8	
7	50/7=7.14	

The bridging callus could not be seen earlier due to cancellous, grafts were placed at fracture site and average time for bridging callus in our study was 7.14 weeks.

XII. Period of Follow up

In our series of 10 cases 2 left follow up. Sixty percent patients came in follow up from 2 months to 4 months and rest 20% patients came more than 6 months.

TABLE XIV : Follow up period.

Period of follow up	No.of cases	Percentage
Lost to follow up	2	20.00
2-4 months	6	60.00
4-6 months	2	20.00
Total	10	100.00

XIII. HOSPITAL STAY

In majority of the cases duration of hospital stay was 2 to 3 weeks. The minimum duration of hospital stay was 2 weeks and the maximum duration was 8 weeks.

XIV : TIME FOR RETURN TO EMPLOYMENT

The average time for return to employement was 9.14 months. 3 cases were the house wives, 3 cases were truck driver, 2 were field workers and 2 left the follow up.

TABLE XV : Average time for return to employment.

Case No.	Time return to work(months)
1	8
2	-
3	9
4	10
5	11
6	-
7	-
8	7
9	10
10	9
10	64/7=9.14

XV. INTERVAL BETWEEN UNION AND INJURY

The average interval between injury and union was 9 months and 8½ months for both septic as well as for clean cases in our study.(Table).

XVI. FAILURE

Study conducted in 10 cases of non union and delayed union during the allocated period. The results of present study showed that seven patients united in 8.5 months time. Two patients left the follow up and in one case first and second operations were unsuccessful. The patient who became first and second

graft unsuccessful was associated with compound fracture shaft of femur (Right) and compound fracture both bone (Right) leg. The injury was twenty four weeks old when first grafting was done. There was no evidence of infection. Second grafting was done after 7 months and failed. There was no evidence of infection. The plaster was removed and patient was asked to walk with crutches, with complication of stiffness in knee since first grafting. Cause of first failure was suspected less amount of grafts and less number of petals.

XVII. INFECTION

Seventy(70%) percent of patients were simple and showed no evidence of infection post operatively. One case had developed the infection and remained for four month post operatively. Some grafts were sequestrated and sinus was present for seven months after operation and healed after extrusion of sequestration.

XVIII. COMPLICATIONS

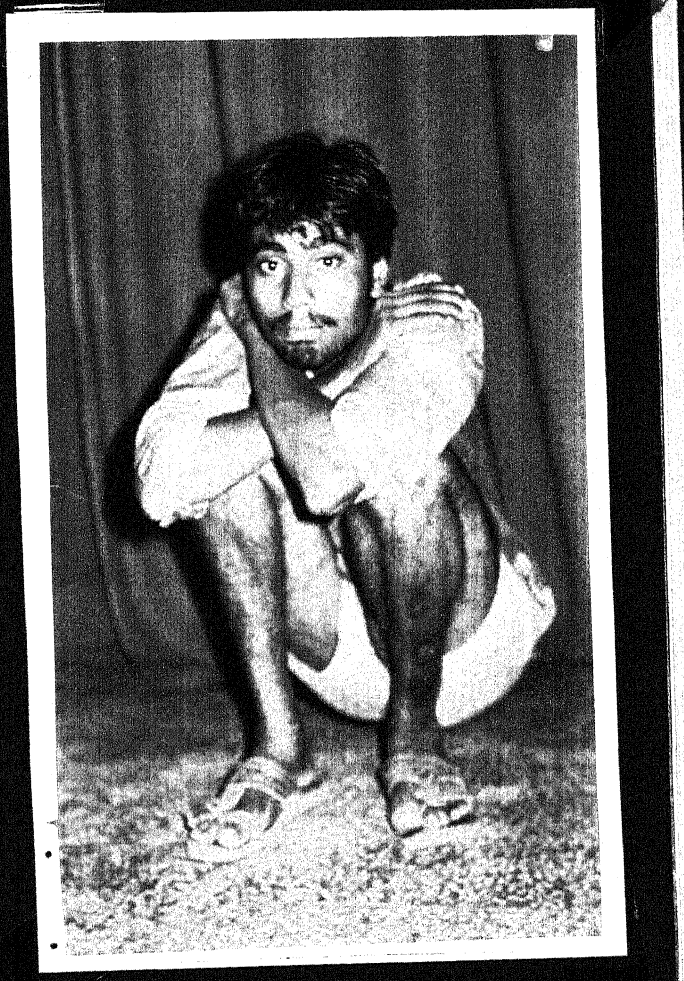
Two patients our of ten, had developed the superficial skin infection which healed in three weeks by prescribing the antibiotics, haematinics and proteins. One patient had developed the arrhythmia and managed. In one patient first and second operations were unsuccessful. One patient had developed deep infection and two patients had left follow up.

Pre-op. X-ray photograph.
of case No. 1.

Post-op. X-ray photograph
of case No. 1.

Post-op. X-ray photograph
showing bridging callus
at VIII week.

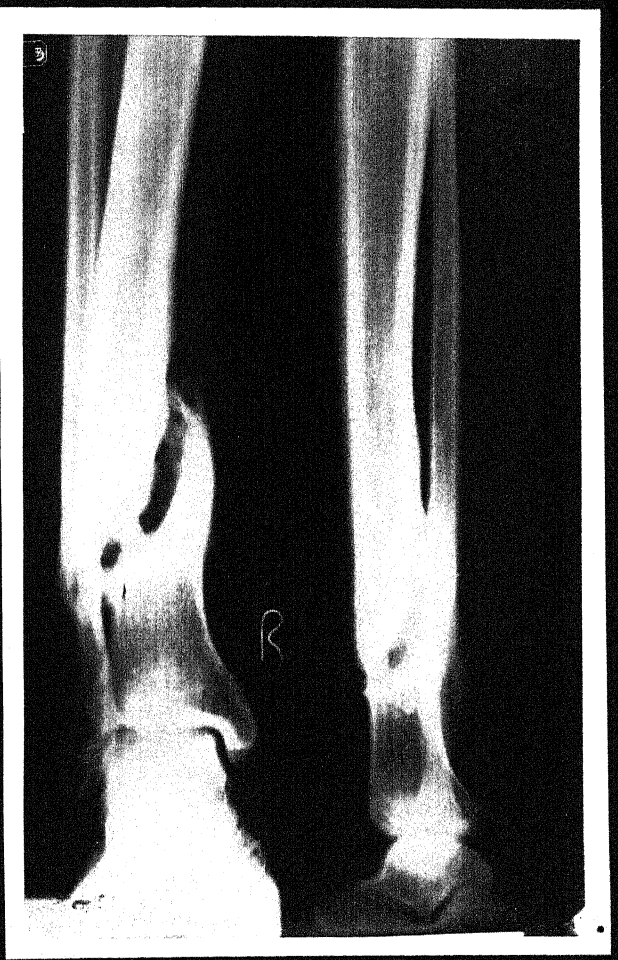
X-ray photograph of same case at 24 weeks.



Same case sitting comfortably at 15 weeks.

Same case taking full weight unsupported, unassisted at 12 weeks.

Same case taking full weight unsupported on affected limb at 15 weeks.



Case No. 2 : Pre-op. X-ray photograph.

Case No. 2 : Post-op. X-ray photograph showing good callus at 10 weeks.

D I S C U S S I O N

D I S C U S S I O N

The study was conducted in the Department of Orthopaedics in patients of delayed and non union. Method was based on modification of Phemister with combination of "Petal" technique of Jarry and Uhthoff (1960). The method is based on the concept that freshening of bone ends is unecessary and the fibrous union between the bone ends acts as stabilizing medium with capacity to reossify with suitable osteogenic stimulus.

The treatment of delayed and non union was started since the time of John Hunter (1886), Macewens and Albee (1915). But classical work on management of delayed and non union was done by Albee (1915). The early history of bone grafting was dominated by teaching and lectures of his works.

Forbes (1961) used autogenous cancellous bone graft taken from ilium in his series of 29 cases. The average age of cases was 37 years with a range from 17 to 65 years. Phemister (1947) in his series reported the age group from 22-65 years. In our series of 10 cases the age group of cases ranged from 19 to 60 years with an average age of 39.5 years.

The male : female ratio in series of Phemister (1947) was 3 : 2. In our study it was 7 : 3.

The maximum time between injury and operation in Phemister series was 12 years. In Forbes series (1961) it was 10 years with a shortest of 11 weeks. In our series longest time between injury and operation was eight months and the shortest 15 weeks (3.75 months).

The proportion of cases which received conservative and operative treatment was as follows. In Forbes series (1961) - 65.4 percent of cases had received conservative treatment and in three cases the previous treatment taken was unknown. In our series 80% cases received conservative treatment while the remaining cases received treatment in the form of nailing/grafting.

The average time of operation in our series was 99.1 minutes. The authors of other series did not give time of operation. The number of blood transfusions required in our series was three. One case needed preoperative blood transfusion and another received one preoperative and one post operative transfusion.

The series of Forbes (1961) had two types of cases - clean and infected. The average time interval between injury and grafting for clean cases was 26 weeks and for infected cases it was 24 weeks. In Phemister(1947) series an average time interval between grafting and injury was 29 weeks (7.33 months). In our series it was 22.3 weeks for all cases.

The post operative immobilization used by various workers was as follows. Phemister (1947) applied A/K POP

cast for 12 weeks and removed it after 12 weeks when clinical union was achieved. Partial weight bearing was started at six weeks with the help of crutches and full weight bearing was advised at 12 weeks. Forbes (1961) applied A/K POP cast for 12 weeks in his series and started partial weight bearing at six weeks with the help of crutches and full weight bearing was started at 12 weeks when solid union was achieved. In our series we have used A/K POP cast for initial six weeks and started non weight bearing ambulation with the help of crutches. The casts were changed at an average interval of 6.4, 11.1 and 15.4 weeks respectively.

The time for hospitalization in our series was 17 days. Other authors did not mention it in their series.

In the Forbes series an average time for grafting and clinical union for clean cases was 15 weeks, and for infected cases 32 weeks. In Phemister series (1947) it was 12 weeks. In series of Sethi and Singhavi (1967) it was six weeks . In our series it was 19 weeks for clean cases and for infected cases was 17 weeks.

An average time interval between injury and clinical union in Forbes (1961) series was 11 months for clean cases and for infected cases it was 14 months. In Phemister series (1947), the time for union was (11.1-12) months for both clean and infected cases. In Sethi series (1967) it was an average of 9 months. In our series an

average time interval for union was 9 months. For clean cases it was 8.8 months and for infected cases it was 8.5 months.

The radiological union in Phemister series (1947) was 20 weeks for clean cases. Series of Forbes (1961) had radiological union for both infected and clean cases at one year. Sethi (1967) reported radiological union at 14 weeks of duration. In our series it was at 7.14 weeks which shows time of bridging callus.

The joint movements after removal of cast in Phemister series (1947) was nil at ankle and knee. After 6 weeks at ankle and knee it was satisfactory and at 12 weeks it was excellent. In our series joints movements at ankle and knee just after removal of cast was nil; and at six weeks movement of ankle was excellent in 80 percent of cases with restriction of movement in two cases. One was operated by K nailing tibia, which was having nail restricting knee movements and other operated twice for non union tibia having failed and had restricted movements at knee and ankle.

The success rate of procedure of Phemister(1947) was 93.8 percent in his series with 6.2 percent of failure. In Forbes series (1961) success rate of his procedure was 96% with 4% of failure in 29 cases. In series of Sethi and Singhavi (1967) it was 96% with 4% of failure in 60 cases. In our series it was 88% in 10 cases with two left follow up and one failed to achieve bony union.

The procedure which we have applied, is short, safe, simple and easy to perform. It has been applied in relatively younger individuals therefore time for union is comparatively less.

In Phemister series (1947) all cases returned to employment after 1 year. In our series the all cases back to work after 9.14 months.

Post operative complications in Phemister series (1947) were sepsis, superficial sepsis in 13 cases and deep in one. Three cases failed to achieve bony union. The superficial infection was either due to previous compound fracture or post operatively. The infection healed and bone grafting was considered in all cases after one to four months of duration. All cases united except one. Forbes (1961) described eight cases of sepsis. Three cases had complete healing of wound and five cases had bony union before wound healing. Our series showed no peroperative complication. The post operative complications in our series were superficial sepsis in three cases which healed in due course, whereas one case had fixed flexion deformity of 30^{o} at knee and other had persistent non union of tibia with persistent stiff knee.

S U M M A R Y

S U M M A R Y

The delayed union and non union has been known since the time of Albee and earlier. The non union has been defined as ununited fracture in which the reparative process have come to complete stand still. There is clinical, radiological and histological evidence of cessation of healing but delayed union is said that reparative process of fracture not reached at the average rate of location and type of fracture.

The patients of delayed union and non union were selected from out patients door department and clinic conducted by Department of Orthopaedics, M.L.B. Medical College, Jhansi.

The fractures of both bone leg are common injury and are treated by conservative method. Most of cases united if treatment given early and adequately. The patients who were not responded to conservative treatment, were advised admission after motivation for surgery.

Total 10 cases were undertaken. There were 7 male patients and remaining three were females. Out of 10 patients, 8 had right leg involvement and two had left leg involvement.

All cases were undergone for thorough clinical radiological, pathological and biochemical investigations.

Procedure was performed and plaster was done. After two months plaster was removed and the X-rays were retaken and compared with preoperative X-rays. Results were graded into four classes - excellent, good, fair and poor or failed depending upon functional assessment, deformity and radiological examinations.

Forbes applied his own technique in 29 cases and achieved the 94 percent of good union in 27 cases. out of 29 patients, but I have added the petal technique of Jarry and Uhthoff with forbes modification and achieved 75 percent of excellent and 12.5 percent of good results with 12.5 percent failure i.e. total good results achieved were 87.5%.

After evaluating the results in present series, it is evident that modified phemister and combination of petal technique of Jarry and Uhthoff have strong indication in the treatment of delayed and non union both the techniques are short, safer and less time consuming.

C O N C L U S I O N

C O N C L U S I O N

From present series of study following conclusions are drawn :-

1. The modified phemister bone grafting with combination of petal technique (Jarry & Uhthoff) is strongly indicated in cases of delayed and non union.
2. Early bone grafting and petalling reduces the time of bony union.
3. Both the procedures are safe, short and easy to perform.
4. Good amount of concellous chip grafts must be taken to achieve good results.
5. Both methods are good biological approach to induce osseous union opposit to mechanical altitude.
6. The study shows that seven fractures united and one failure occurred. This did not unite even after 2nd operation. Two cases were lost to the follow up. Our study of ten patients showed that of 87.5 percent of bony union with 12.5 percent of failed or poor results.
7. Present series had 70 percent of malss and 30 percent females and majority of the cases had right leg involvement.

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